ARTIFICIAL INTELLIGENCE
(CSEN 3111)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) A state space can be described as
(a) representation of your problem with variables and parameters
(b) formulation of your design
(c) definition to a problem
(d) the whole problem.

(ii) Which of the following is an example of informed search strategy?
(a) A* (b) Iterative deepening (c) DFS (d) Depth limited.

(iii) A Bayesian network is
(a) an undirected graph (b) tree (c) DAG (d) all of these.

(iv) What is the correct translation of the following English sentence into FOPL?
"Some real numbers are rational"
(a) ∃x (real(x) ∨ rational(x)) (b) ∀x(real(x)→ rational(x))
(c) ∃x(real(x) ∧ rational(x)) (d) ∃x(rational(x) → real(x)).

(v) Inheritable knowledge is best represented by
(a) Semantic network (b) Database (c) FOPL (d) None of these.

(vi) Which of the following search methods take less memory?
(a) DFS (b) BFS (c) Uniform Cost (d) Bi-directional.

(vii) In MINIMAX algorithm search process follows
(a) BFS Fashion (b) DFS Fashion (c) both (a) and (b) (d) neither (a) nor (b).

(viii) An 'agent'
(a) perceives its environment through sensors and acting upon that environment through actuators
(b) takes input from the surroundings and uses its intelligence and performs the desired operations
(c) is a embedded program controlling line following robot
(d) all of the mentioned.

(ix) Which of the following reasoning methods PROLOG follows at the time of satisfying a goal?
(a) Forward (b) Backward (c) Both (a) and (b) (d) None of these.

(x) If h(n) is the estimate of the cost of a minimum cost path from n to a goal node and h*(n) is the actual cost of a minimal cost path from n to a goal node, then the heuristic h(n) is said to be admissible if for each node n belonging to the graph
(a) $0 \le h(n) \le h^*(n)$ (b) $0 \le h^*(n) \le h(n)$ (c) $h(n) = h^*(n)$ (d) none of these.

Group - B

2. (a) Consider the water-jug puzzle, where we are given a 3-litre jug, named THREE, and a 4-litre jug, named FOUR. Initially, both THREE and FOUR are empty. Either jug can be filled with water from a tap, T, and we can discard water from either jug down a drain, D. Water may be poured from one jug into the other. There is no additional measuring device. We want to find a set of operations that will leave precisely two litres of water in FOUR.
(i) Give the state-space representation of the problem by mentioning the initial state, goal state, possible operators and the pre-condition of the operators.
(ii) Provide at-least one solution of the given problem following the same state-space representation given at part (i).
[(CSEN 3111.1)(Remember, Understand/LOCQ)]

(b) Determine whether each of the following sentence is satisfiable, contradictory or valid, where P, Q & R are propositions:
(i) (P & Q) ∨ ¬ (P & Q) (ii) (P∨Q) → (P & Q) (iii) (P & Q) → R ∨ ¬ Q (iv) (P∨Q) & (P∨¬Q) ∨ P
[(CSEN3111.2 (Remember/LOCQ)]

(c) Suppose you have the following search space:

State	next	cost
A	B	4
A	C	1
B	D	3
B	E	8
C	C	0
C	D	2
C	F	6
D	C	2
D	E	4
E	G	2
F	G	8

If the initial state is **A** and the goal state is **G,** then show how DFS would create a search tree to find a path from the initial state to the goal state. At each step of the search algorithm, show which node is being expanded, and also report the eventual solution found by each algorithm, and the respective solution cost. [(CSEN3111.4)(Apply/IOCQ)]

(3 + 2) + 2 + 5 = 12

3. (a) You know that for a branching factor of b, depth of goal node d, the number of nodes expanded by iterative-deepening search is given by –

$$(d + 1)b^0 + (d)b^1 + (d - 1)b^2 + \ldots\ldots\ldots + (1)b^d$$

Note that it is an Arithmetico-geometric series. Hence find the closed form for this expression. [(CSEN3111.4)(Apply/IOCQ)]

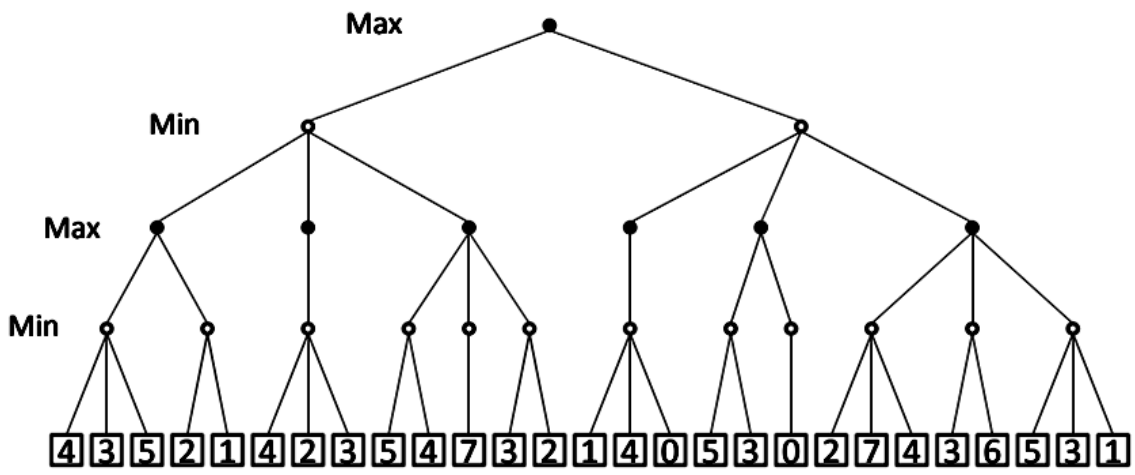
(b) Prove that for a branching factor of b, depth of goal node d, the ratio of the number of nodes expanded by iterative-deepening search w.r.t. breadth first search is given by b/(b – 1). [(CSEN3111.4)(Analyze/IOCQ)]

(c) Hence show that for b = 10 & deep goals, iterative-deepening search expands only about 11% more nodes than a breadth-first search expands. [(CSEN3111.4)(Evaluate/HOCQ)]

5 + 4 + 3 = 12

Group – C

4. (a) Consider the following game tree:



(i) Use the MINIMAX algorithm to determine the first player's best move

(ii) What nodes would not need to be examined using α – β cutoff algorithm along with the type of cutoff – assuming that nodes are examined in left-to-right order? [(CSEN3111.4)(Apply/IOCQ)]

(b) What is the drawback of Hill Climbing algorithm and briefly explain what will be your approach to overcome the drawback? [(CSEN3111.4)(Understand/LOCQ)]

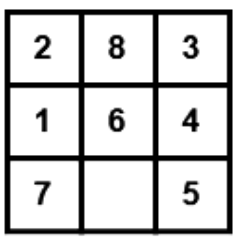
(c) If h is consistent, then prove that h(n) ≤ c(n, n') + h(n') is applicable for any descendant n' of n. [(CSEN3111.4)(Analyze/IOCQ)]

(2 + 3) + (2 + 2) + 3 = 12

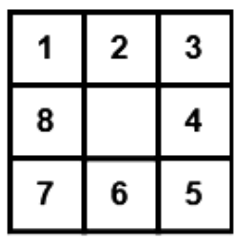
5. (a) Given an initial state of a 8-puzzle problem and final state to be reached

Find the most cost-effective path to reach the final state from initial state using A* Algorithm.

Consider g(n) = Depth of node and h(n) = Number of misplaced tiles. [(CSEN3111.6)(Apply/IOCQ)]



Initial State



Final State

(b) Given a cryptarithmetic problem, i.e., B A S E + B A L L = G A M E S

You are constrained by the following conditions,

- There should be a unique digit to be replaced with a unique alphabet.
- The result should satisfy the predefined arithmetic rules, i.e., 2 + 2 = 4, nothing else.
- Digits should be from 0-9 only.
- There should be only one carry forward, while performing the addition operation on a problem.

(i) Formulate the above problem as a CSP problem by mentioning variables, domain of each variable and the constraints. You are also supposed to provide the constraint graph.

(ii) Find a solution that have unique values to all the alphabets satisfying the constraints. [(CSEN3111.4)(Apply/IOCQ)]

8 + 4 = 12

Group - D

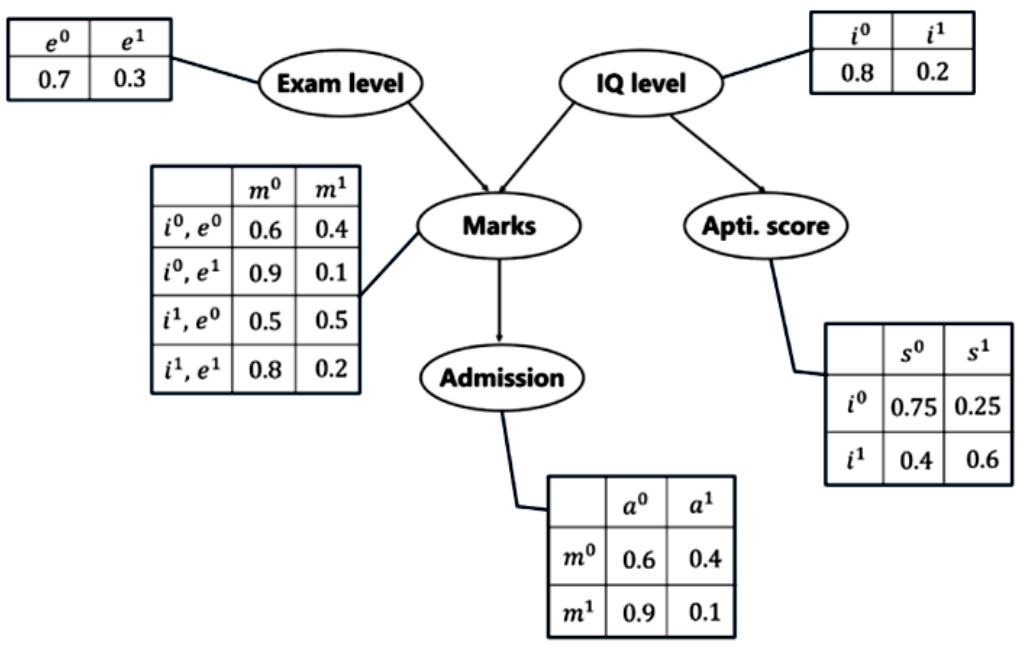
6. (a) From the given English sentences,
1. John likes all kind of food.
2. Apple and vegetable are food
3. Anything anyone eats and not killed is food.
4. Anil eats peanuts and still alive
5. Harry eats everything that Anil eats.

Prove by resolution that: John likes peanuts.
Note: Show all the steps from conversion to resolution very clearly. [(CSEN3111.3)(Apply/IOCQ)]

(b) Write a PROLOG program to separate all the vowels and consonant from a given list of alphabets.
Sample Input - separateVC([a,e,b,x,i,d,u,o],V,C).
Sample Output - V = [a,e,i,u,o];
C = [b,x,d]. [(CSEN3111.5)(Apply/IOCQ)]

8 + 4 = 12

7. (a) Consider the following Bayesian Network:
The events given in the table are as follows,
Exam Level (e)
IQ Level (i)
Aptitude Score (s)
Marks (m)
Admission (a)
Normal and complement of any event has been represented as 0 and 1 respectively.



e^0	e^1
0.7	0.3

i^0	i^1
0.8	0.2

	m^0	m^1
i^0, e^0	0.6	0.4
i^0, e^1	0.9	0.1
i^1, e^0	0.5	0.5
i^1, e^1	0.8	0.2

	s^0	s^1
i^0	0.75	0.25
i^1	0.4	0.6

	a^0	a^1
m^0	0.6	0.4
m^1	0.9	0.1

(i) Calculate the probability that in spite of the exam level being difficult, the student having a low IQ level and a low Aptitude Score, manages to pass the exam and secure admission to the university.
(ii) Find the probability that the student has a High IQ level and Aptitude Score, the exam being easy yet fails to pass and does not secure admission to the university. [(CSEN3111.3)(Apply/IOCQ)]

(b) What are the different approaches to knowledge representation? [(CSEN3111.2)(Remember/LOCQ)]

(c) Write a PROLOG program to find the sum of all the even numbers and odd numbers from a given list.
Sample Input - oddevenSum([4,9,3,7,8,1],O,E).
Sample Output - O = 20;
E = 12. [(CSEN3111.5)(Apply/IOCQ)]

(3 + 3) + 3 + 3 = 12

Group – E

8. (a) Define entropy of training set D.
Define information gain of a training set D while splitting on an attribute A. Assume that A has m distinct values in D. [(CSEN3111.4)(Remember/LOCQ)]

(b) Calculate the information gain corresponding to features like, Weather, Parents and Financial Condition in selecting an attribute to construct (induct) a decision tree from the data provided in the following table. Also mention the attribute you will select based on the calculated information gain. Consider the attribute named as Decision as the class label. (Note: No need to draw the whole decision tree) [(CSEN3111.4)(Apply/IOCQ)]

Weekend	Weather	Parents	Financial Condition	Decision
W1	Sunny	Yes	Rich	Cinema
W2	Sunny	No	Rich	Play Tennis
W3	Windy	Yes	Rich	Cinema
W4	Rainy	Yes	Poor	Cinema
W5	Rainy	No	Poor	Stay in
W6	Rainy	Yes	Poor	Cinema
W7	Windy	No	Poor	Cinema
W8	Windy	No	Rich	Shopping
W9	Windy	Yes	Rich	Cinema
W10	Sunny	No	Rich	Play Tennis

(2 + 2) + 8 = 12

9. (a) Consider the following data table:

Age	Income	Married	Health	Class
Young	High	No	Fair	No
Young	High	No	Good	No
Middle	High	No	Fair	Yes

Age	Income	Married	Health	Class
Old	Medium	No	Fair	Yes
Old	Low	Yes	Fair	Yes
Old	Low	Yes	Good	No
Middle	Low	Yes	Good	Yes
Young	Medium	No	Fair	No
Young	Low	Yes	Fair	Yes
Old	Medium	Yes	Fair	Yes
Young	Medium	Yes	Good	Yes
Middle	Medium	No	Good	Yes
Middle	High	Yes	Fair	Yes
Old	Medium	No	Good	No

Using the data as shown in the above Table, predict the class label of the record X = (Age= "Young", Income = "Medium", Married = "Yes", Health = "Fair") using Naive-Bayes classifier. [(CSEN3111.4)(Apply/IOCQ)]

(b) What do you mean by supervised and unsupervised learning? Explain with suitable example. [(CSEN3111.4)(Remember, Understand/LOCQ)]

8 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	22.92	73.96	3.13

Course Outcome (CO):

After the completion of the course students will be able to

CSEN3111.1. Remember and understand the basic principles of state-space representation of any given problem, various searching and learning algorithms, game playing techniques, planning algorithms, logic theorem proving, natural language processing etc.

CSEN3111.2. Comprehend the importance of knowledge as far as intelligence is concerned and the fundamentals of knowledge representation and inference techniques.

CSEN3111.3. Use the knowledge gained so far to logically infer new knowledge in both certain and uncertain environments.

CSEN3111.4. Illustrate various AI searching algorithms, like state-space search algorithm, adversarial search algorithm, constraint satisfaction search algorithm and different learning models and planning techniques as and when required.

CSEN3111.5. Apply the working knowledge of Prolog/ Lisp in order to write simple Prolog/Lisp programs and to explore more sophisticated Prolog/Lisp code on their own.

CSEN3111.6. Design and evaluate the performance of various heuristics applied to real-world situations.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.